

# CLAIMS

1. A method for testing of a communication network, using a plurality of traffic agents coupled to communicate via the network, the method comprising:

transmitting a sequence of data packets via the network from a first one of the traffic agents to a second one of the traffic agents;

creating a record of the packets in the sequence that were not received at the second traffic agent; and

assessing a relative irregularity in the occurrence of packet loss, based on the record.

2. A method according to claim 1, wherein assessing the relative irregularity of packet loss comprises detecting bursts of lost packets.

3. A method for testing of a communication network, using a plurality of traffic agents coupled to communicate via the network, the method comprising:

transmitting a sequence of data packets via the network from a first one of the traffic agents to a second one of the traffic agents;

determining an order of arrival of the packets at the second traffic agent; and

comparing the order of arrival to an order in which the packets were transmitted.

4. A method according to claim 3, wherein comparing the order of arrival comprises finding a measure of discrepancy between the order of arrival and the order in which the packets were transmitted.

5. A method for testing of a communication network, using a plurality of traffic agents coupled to communicate via the network, the method comprising:

transmitting a sequence of data packets via the

network from a first one of the traffic agents to a second one of the traffic agents;

determining respective arrival times of the packets in the sequence;

determining a packet transmission delay between the traffic agents responsive to the arrival times; and

finding a change in the transmission delay over time.

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6. A method for testing of a communication network, using a plurality of traffic agents coupled to communicate via the network, the method comprising:

transmitting a sequence of data packets via the network from a first one of the traffic agents to a second one of the traffic agents, the sequence comprising both communication test packets and packets associated with an application that is accessed via the network;

recording arrival characteristics of the packets in the sequence, responsive to receiving the packets at the second traffic agent; and

observing a difference in the arrival characteristics of the communication test packets relative to those of the packets associated with the application.

7. A method for testing of a communication network, using a plurality of traffic agents coupled to communicate via the network, the method comprising:

transmitting a first sequence of data packets via the network from a first one of the traffic agents to a second one of the traffic agents;

transmitting a second sequence of data packets via the network from the second one of the traffic agents, responsive to receiving the data packets in the first sequence, to a third one of the traffic agents;

recording arrival characteristics of the packets in the second sequence, responsive to receiving the packets at the third traffic agent; and

comparing the arrival characteristics of different packets in the sequence so as to determine a measure of variability in transmission of the packets via the network.

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8. A method for testing of a computer application accessed via a communication network, using a plurality of traffic agents coupled to communicate via the network, the method comprising:

running an instance of the application on a first computer coupled to the network, on which a first one of the traffic agents is also running;

exchanging test data packets via the network between a second one of the traffic agents, running on a second computer coupled to the network, and the first traffic agent, so as to determine test packet exchange characteristics generally independent of the application;

exchanging application data packets via the network between the second computer and the instance of the application running on the first computer, so as to determine application packet exchange characteristics; and

comparing the exchange characteristics of the application and test packets.

9. A method according to claim 8, wherein running the instance of the application on the first computer comprises running an application server, and wherein exchanging the application data packets comprises transmitting application client messages from the second computer to the first computer.

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10. A method according to claim 8, wherein running the instance of the application comprises running a distributed computing application on the first computer, and wherein exchanging the application data packets comprises running another instance of the application on the second computer.
11. A method according to claim 8, wherein comparing the exchange characteristics comprises comparing a delay in the exchange of application data between the first and second computers relative to the exchange of test data.
12. A method for determining a round-trip transmission delay in a communication network, comprising:
  - transmitting a first data packet through the network at a first transmit time, from a first endpoint of the network to a second endpoint of the network;
  - receiving the first data packet at the second endpoint at a first receive time;
  - transmitting a second data packet through the network at a second transmit time, substantially independent of the first transmit and receive times, from the second endpoint to the first endpoint;
  - receiving the second data packet at the first endpoint at a second receive time; and
  - comparing the first and second transmit times and the first and second receive times so as to determine the round-trip transmission delay.
13. A method according to claim 12, wherein transmitting the second data packet comprises transmitting the second packet without waiting to receive the first data packet at the second endpoint.
14. A method according to claim 12, wherein comparing the first and second transmit times and the first and

second receive times comprises using transmit and receive times recorded in accordance with different clocks maintained at the first and second endpoints.

15. A method according to claim 14, wherein comparing the first and second transmit times and the first and second receive times comprises canceling out a relative offset between the different clocks, substantially without an *a priori* knowledge of the offset.

~~16.~~ A method for testing of a communication network, using a plurality of traffic agents coupled to communicate via the network and having respective agent clocks that are generally independent of one another, the method comprising:

determining at a testing center a start time at which a test of the network is to begin;

sending respective start messages to the traffic agents, each start message containing the start time and a time of sending the start message determined with reference to a local clock maintained by the testing center; and

synchronizing initiation of the test by the traffic agents, responsive to the respective start messages.

17. A method according to claim 16, wherein determining the start time comprises choosing a time to start the test that is delayed relative to expected times of sending the start messages.

18. A method according to claim 16, wherein synchronizing the initiation of the test comprises starting the test at each of the traffic agents at the start time, as indicated by the respective agent clock, corrected responsive to the time of sending contained in the respective start message.

19. Apparatus for testing of a communication network, comprising:

a first traffic agent, coupled to transmit a sequence of data packets via the network; and

a second traffic agent, coupled to receive the data packets transmitted by the first traffic agent and to record, responsive to receiving the data packets, an indication of the packets in the sequence that were lost in transmission,

wherein a relative irregularity in the occurrence of packet loss is assessed based on the indication.

20. Apparatus according to claim 19, and comprising a testing center, coupled to the network, which is adapted to receive the indication of the packets that were lost in transmission and to assess the relative irregularity in the occurrence of packet loss.

21. Apparatus for testing of a communication network, comprising:

a first traffic agent, coupled to transmit a sequence of data packets via the network; and

a second traffic agent, coupled to receive the data packets transmitted by the first traffic agent and to record, responsive to receiving the data packets, an order of arrival of the packets at the second traffic agent,

wherein a measure of discrepancy is determined between the order of arrival and an order in which the packets were transmitted.

22. Apparatus according to claim 21, and comprising a testing center, coupled to the network, which is adapted to receive the recorded order of arrival of the packets and to determine the measure of the discrepancy.

23. Apparatus for testing of a communication network, comprising:

a first traffic agent, coupled to transmit a sequence of data packets via the network; and

a second traffic agent, coupled to receive the data packets transmitted by the first traffic agent and to record, responsive to receiving the data packets, respective arrival times of the packets in the sequence at the second traffic agent,

wherein a change in a transmission delay over time between the first and second traffic agents is detected responsive to the recorded arrival times.

24. Apparatus according to claim 23, and comprising a testing center, coupled to the network, which is adapted to receive the recorded arrival times and detect the change in the transmission delay. (1)

25. Apparatus for testing of a computer application accessed via a communication network, comprising:

a first computer, coupled to communicate via the network, and configured both to run an instance of the application and to act as a first traffic agent; and

a second computer, coupled to communicate via the network with the first computer, and configured both to act as a second traffic agent so as to exchange test data packets via the network with the first traffic agent, generally independent of the application, and to exchange application data packets via the network with the instance of the application running on the first computer, so as to determine and compare characteristics of the exchange of the test data with corresponding characteristics of the exchange of the application data.

26. Apparatus according to claim 25, wherein the

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instance of the application running on the first computer comprises an application server, and wherein the second computer acts as a client of the application.

27. Apparatus according to claim 25, wherein the characteristics that are compared comprise a delay in the exchange of application data between the first and second computers relative to the exchange of test data.

28. Apparatus for determining a round-trip transmission delay in a communication network, comprising:

a first traffic agent, adapted to be coupled to a first network endpoint and configured to transmit a first data packet through the network at a first transmit time, from the first endpoint to a second endpoint of the network; and

a second traffic agent, adapted to be coupled to the second network endpoint, so as to receive the first data packet at a first receive time and to transmit a second data packet through the network to the first network endpoint at a second transmit time, substantially independent of the first transmit and receive times, to be received by the first traffic agent at a second receive time,

wherein the first and second transmit times and the first and second receive times are compared so as to determine the round-trip transmission delay.

29. Apparatus according to claim 28, wherein the second traffic agent is configured to transmit the second data packet without waiting to receive the first data packet.

30. Apparatus according to claim 28, wherein the first and second traffic agents record the transmit and receive times in accordance with different, respective clocks maintained at the first and second endpoints, and wherein



a relative offset between the different clocks is canceled out, substantially without an *a priori* knowledge of the offset.

31. Apparatus for testing of a communication network, comprising:

a plurality of traffic agents, coupled to communicate via the network and having respective agent clocks that are generally independent of one another; and

a testing center, having a local clock and adapted to determine a start time at which a test of the network is to begin, and to send respective start messages to the traffic agents, each start message containing the start time and a time of sending the start message determined with reference to the local clock, so that the traffic agents synchronize initiation of the test responsive to the respective start messages.

32. Apparatus according to claim 31, wherein each of the traffic agents initiates the test at the start time, as indicated by the respective agent clock, corrected responsive to the time of sending contained in the respective start message.

33. Apparatus for testing of a communication network, comprising:

a first traffic agent, coupled to transmit a first sequence of data packets via the network;

a second traffic agent, coupled to receive the data packets transmitted by the first traffic agent and to transmit, responsive to receiving the data packets in the first sequence, a second sequence of data packets via the network to a third traffic agent; and

a third traffic agent, coupled to receive the data packets transmitted by the second traffic agent and to

record, responsive to receiving the data packets, arrival characteristics of the packets in the second sequence,

wherein the arrival characteristics of different packets are compared so as to determine a measure of variability in transmission of the packets via the network.

34. A computer software product for testing of a communication network, the product comprising a computer-readable medium containing program instructions, which instructions, when executed by first and second computers coupled to communicate via the network, cause the first computer to transmit a sequence of data packets via the network to the second computer, and further cause the second computer to receive the data packets and to record arrival characteristics of the received packets, wherein the arrival characteristics of different packets in the sequence are compared so as to determine a measure of variability in transmission of the packets via the network, wherein the measure of variability is a measure relating to a quality selected from a group of qualities consisting of changes in packet transmission delay, loss of transmitted packets and an order in which transmitted packets are received.

35. A product according to claim 34, wherein the program instructions, when executed by a third computer, cause the third computer to act as a testing center, which receives the arrival characteristics from the first and second computers and determines the measure of variability.

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36. A computer software product for testing of a computer application accessed via a communication network, the product comprising a computer-readable

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medium containing program instructions, which instructions, when executed by first and second computers coupled to communicate via the network, wherein the first computer is also running an instance of the application, cause the first and second computers to exchange test data packets via the network, generally independent of the application, so as to determine test packet exchange characteristics, and to exchange application data packets via the network between the second computer and the instance of the application running on the first computer, so as to determine application packet exchange characteristics, whereby the exchange characteristics of the application and test packets are compared.

37. A product according to claim 36, wherein the instance of the application on the first computer comprises an application server, and wherein the application data packets comprise application client messages between the second computer and the first computer.

38. A computer software product for determining a round-trip transmission delay in a communication network, the product comprising a computer-readable medium containing program instructions, which instructions, when executed by first and second computers coupled to communicate via the network, cause the first computer to transmit a first data packet through the network to the second computer at a first transmit time, and cause the second computer to receive the first data packet at a first receive time and to transmit a second data packet through the network to the first computer at a second transmit time, substantially independent of the first transmit and receive times, which second data packet is received by the first computer at a second receive time,

wherein the first and second transmit times and the first and second receive times are compared so as to determine the round-trip transmission delay.

39. A computer software product for testing of a communication network, the product comprising a computer-readable medium containing program instructions, which instructions, when executed by a plurality of computers coupled to communicate via the network and having respective local clocks that are generally independent of one another, cause a first one of the computers to determine a start time at which a test of the network is to begin and to send respective start messages to the other computers, each start message containing the start time and a time of sending the start message determined with reference to the local clock maintained by the first computer, and which instructions further cause the other computers to synchronize initiation of the test, responsive to the respective start messages.